ACANTHODRILIDAE AND EUDRILIDAE (OLIGOCHAETA) FROM GHANA

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CONTENTS

SYNOPSIS

Fifteen species of Acanthodrilidae and Eudrilidae are reported in a collection of earthworms made in Ghana by Miss M. A. Tazelaar. Six are new, four being species of *Millsonia* and two are species of *Hyperiodrilus* ; keys are provided to all species of these genera.

INTRODUCTION

Few oligochaetes have previously been reported from Ghana (Omodeo, 1958 : 100 *et seq.*) so it is not surprising that when new collections are examined they are found to contain a high percentage of hitherto undescribed forms (Clausen, 1963 and *in prep.:* Sims, 1964). While a member of the staff of University College Ghana, Miss Mary A. Tazelaar collected earthworms in several localities in Ghana, including Togoland, about half of the species have proved to be new. Among the material obtained, the families Acanthodrilidae* and Eudrilidae are best represented by a total of fifteen species which are reported here. Six are described for the first time, four being species of *Millsonia* Beddard, 1894, and two being species of *Hyperiodrilus* Beddard, 1891 *a*. In addition, one new species of *Libyodrilus* Beddard, 1891 *c*, will be described by Mrs. Clausen (1965) and three other Eudrilid species are

*Subfamily Octochaetinae.

listed which were described elsewhere and separated as a new genus, *Legonea*, (Clausen, 1963 ; Sims, 1964). The purpose of this report is to place on record details of the new material of the families Acanthodrilidae and Eudrilidae and, in particular, to describe the new species. Zoogeographical and other discussions are not attempted since it would appear to be premature at this stage to discuss the significance of the new species and records.

I wish to express my gratitude to Miss Tazelaar for collecting these earthworms and for presenting them to the British Museum (Natural History). My thanks are also due to Dr. M. Dzwillo, Staatsinstitut und Zoologisches Museum, for his courtesy in giving me access to material in his charge when I visited Hamburg. Finally, I must thank Mrs. Martha Weis Clausen for her friendly co-operation when we found our investigations overlapping.

TAXONOMY

ACANTHODRILIDÆ (OCTOCHÆTINAE)

Benhamia esca (Stephenson, 1931)

Dichogaster esca Stephenson, 1931, Proc. zool. Soc. Lond., **1931** : 71 : Begoro, Akim, Ghana.

2 clitellate, 1 aclitellate specimen, Tafo, 17th October, 1952. 10 clitellate specimens, Tafo, 14th May, 1954. 1 clitellate specimen, Prempeh College, grounds, Kumasi, 17th November, 1955.

Description. *External Characters*. Length 150–233 mm., diameter 6–7 mm. Segments 206–272. Cuticle non-iridescent ; epidermis unpigmented, colour pale straw (specimens preserved in alcohol). First dorsal pore ?12/13, 13/14–18/19. Prostomium large, prolobous.

Setae ventral, closely paired. In the pre-clitellate region the setal areas are raised giving a triannulate appearance. Setal formula similar throughout body, *aa* : *ab* : *bc* : *cd*=4·5 : 1 : 3 : 1, *dd*=$\frac{3}{4}$ circumference (*ab* is slightly greater than *cd*, the difference being equal to about the diameter of one seta). Setae in the region of the spermathecal pores unspecialised. Penial setae present *xvii*, *xix* in setal ring, midway between *b* and *c*, other setae absent *xvii–xix*. Penial setae usually single, sometimes two or three present ; when multiple usually of differing lengths. Each penial seta is about 3 mm. long and proximally 0·1 mm. in diameter (Fig. 1a). The shaft is gently curved and tapers distally to a shoulder four-fifths along the length of the seta from where it becomes more tooth-like. Proximally to the shoulder the shaft is ornamented with numerous distally directed spines (Fig. 1b) ; the tooth-like, distal one-fifth is smooth.

Clitellum annular *xiv*, *xv–xx* (6 segments), extending dorsally to *xiii*, *xiv* and *xxi* (8 segments).

Genital field concave between setal lines *cc* on *xvii–xix* with small raised pads (Fig. 1c).

Male pores paired *xviii* midway between setal lines *b* and *c*. Each lies in a convex, outwardly curving seminal groove which passes between the penial setae in *xvii* and *xix*. Prostatic pores paired *xvii*, *xix* medially to setal line *c* and laterally to the

penial setae at the ends of the seminal grooves, each pore is surrounded by a pair of tumid lips.

Female pores inconspicuous, paired *xiv* midway between setal lines *a* and *b*, $\frac{1}{2}$ *ab* anteriorly to the setal ring.

Spermathecal pores large, paired in furrows 7/8, 8/9 in setal line *b* ; with the ectal end of each spermathecal duct protruding as a small papilla. The area of the ventral surface bounded by the four spermathecal pores is swollen and the intersegmental furrows in this region deeper.

Genital papillae single, median ventral in furrows 10/11–14/15, glandular in appearance ; sometimes 16/17, 19/20 occasionally 18/19 when slightly pigmented ; paired 17/18. The posterior papillae are present only when the genital field is fully developed.

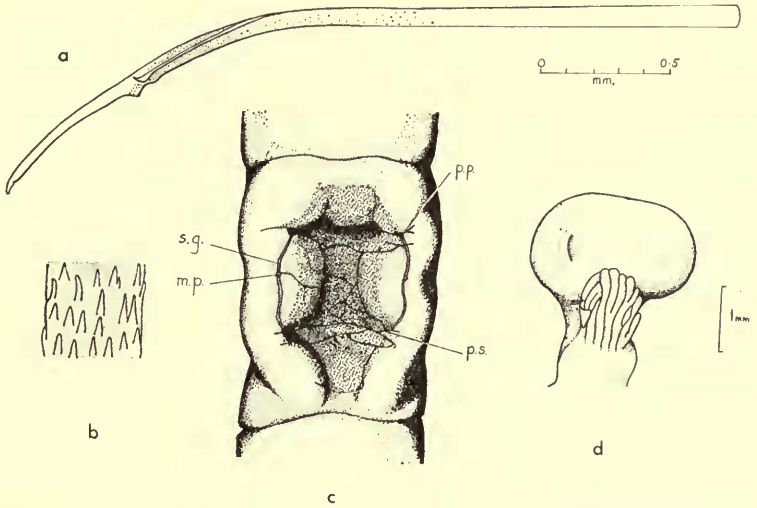

FIG. 1. *Benhamia esca* : a.—Penial seta (low power). b.—Penial seta (high power) showing spines, each spine is 30–50μ in length. c.—Genital field ; *m.p.*, male pore ; *p.p.*, prostatic pore ; *p.s.*, position of penial seta ; *s.g.*, seminal groove. d.—Right posterior spermatheca, dorsal view.

Internal Characters. First septum 4/5, 4/5–12/13 thickened, septa 4/5–6/7 being very thick. Septa 4/5–11/12 conical.

A large pharynx extends posteriorly to *iii*, in *iv* a dilated oesophagus leads from the postero-ventral surface of the pharynx to the first gizzard in *v*. Two gizzards, one in each of *v* and *vi*, are joined intersegmentally by a short, narrow portion of oesophagus. Both are heart-shaped, the anterior gizzard being slightly larger and more rounded ; in both there is an anterior " auricular " portion which is less strongly muscular than the larger, posterior " ventricular " portion. Gizzards considerably displaced posteriorly, gizzard in *vi* lies within the parietes of *xi*. Oesophageal glands paired *xiv*, *xv*, *xvi* ; those in *xiv* being the smallest and in *xvi* the largest. The glands of each side intercommunicate and are attached to the oesophagus by a paired duct in *xv*. (Each pair of glands is supplied with paired segmental blood vessles.) Intestine begins in *xx* and the typhlosole arises in *xxi*

reaching full size in *xxiv* as a broadly triangular ridge along the dorsal surface of the lumen of the intestine.

The dorsal vessel extends anteriorly to *iii* where it passes into the pharynx, in *xiii–xv* it is apparently contractile being moniliform in appearance. Commissural vessels present *v–xiii* (in one specimen also *xiii* but slender and non-contractile) ; contractile as functional lateral hearts only in *x–xii*. The commissural vessels join the dorsal and ventral blood vessels. A supraoesophageal blood vessel can be traced between the posterior end of the hinder gizzard in *vi* and the anterior oesophageal gland in *xiv*, it is interconnected with the dorsal vessel by the commissural vessels in *vii–xii*. Suboesophageal and subneural blood vessels not seen. (The anterior blood vessels are difficult to trace due to the great displacement of the foregut and the thick anterior septa).

Testes holandric, funnels large, paired in *x*, *xi*. Seminal vesicles small, paired in *xi*, *xii*, granular in appearance. Vesa deferentia slender, almost transparent, those of each side lying closely together on the parietes level with the ectal regions of the prostatic ducts. They pass into small bilobed, muscular, ejaculatory pouches embedded in the parietes in *xviii*, each pouch is about 1 mm. in diameter and partly covered with parietal muscle strands. Prostates tubular, paired in *xvii*, *xix*, each is highly convoluted and nearly 20 mm. long when unravelled and 1 mm. in diameter. Ectally each prostate becomes slenderer and muscular before dilating slightly into a strongly muscular portion which passes into the parietes laterally to the large sac of a penial seta.

Ovaries and funnels small, paired *xiii*.

Spermathecae paired, lying in the coelom apparently between septa 5/6, 6/7, latero-ventrally to the posterior region of the pharynx (the displacement of the foregut confuses the situation of the anterior organs). Each spermatheca is approximately 3 mm. long and comprises a large ampulla and short slightly dilated adiverticulate duct (Fig. 1d).

Excretory system meronephridial.

Remarks. This species has not been recorded since Stephenson described it on two specimens with imperfectly developed clitella and genital fields. The present series agrees largely with the types, particularly in the form of the penial setae but there are a few differences due, presumably, to age. Apart from two specimens which closely resemble the type specimens all others appear to be more fully developed. New information is given, therefore, of the genital field, spermathecae, spermathecal and female pores, in addition to other minor details.

Stephenson reported that the intestine began in *xvii* whereas in the new material it begins in *xx*. This discrepancy cannot be resolved from a detailed examination of the types since the specimens are partly contracted, the prostates are poorly developed and the structures in the prostatic region have been dissected. There is no doubt about the position of the anterior end of the intestine in the present series since, like in ripe individuals of other related species, segments *xvii–xix* are each almost equal in length to two or three intestinal segments and the posterior region of the oesophagus can clearly be seen passing through them.

Millsonia pumilia sp. nov.

5 clitellate specimens. Forest near Prempeh College, Kumasi. 21 March, 1956. Holotype, British Museum (Natural History) Register No. 1964.2.15 ; paratypes, British Museum (Natural History) Register No. 1964.2.16–19.

Diagnosis. *External Characters*. Length 94–112 mm., diameter 3 mm.. Segments 193–242. Unpigmented. First dorsal pore ? 9/10, 10/11. Prolobous. Setae small, ventral, closely paired. Genital and penial setae absent. Clitellum *xiii–xix* (7 segments), saddle-shaped. Male pores paired *xviiii*. Female pores closely paired *xiv*. Spermathecal pores large, paired 7/8, 8/9 extending across setal lines *ab*. Genital papillae paired in setal line *b*, 13/14, 14/15, 15/16 (3 pairs).

Internal Characters. First septum 4/5, 4/5–10/11 thickened. Gizzards *v*, *vi*. Oesophageal glands paired *xv–xvii*. Intestine begins *xix*, intestinal caeca *xxvii–xxx* (4 pairs). Typhlosole ribbon-like, arising *xxvii*. Last lateral hearts *xii*. Holandric, testes paired in testes-sacs *x*, *xi*. Seminal vesicles paired *xi*, *xii*. Prostates paired *xvii*, *xix*, tubular, straight or simply looped. Ovaries paired *xiii*. Spermathecae paired *viii*, *ix*, posterior pair larger ; each with rounded ectal diverticulum and digitiform diverticulum $\frac{1}{3}$ distance from ectal end of duct, ampulla simple. Meronephridial.

Description. *External Characters*. Length 94–112 mm., diameter 3 mm. Segments 193–242. Cuticle with slight blue-green iridescence particularly in the pre-clitellar region. Epidermis unpigmented (white in alcohol preserved specimens), body contents seen through the body wall. First dorsal pore ?9/10, 10/11, pores sometimes occluded in the clitellar region. Prostomium prolobous. Segments between 8/9 and clitellar region biannulate usually with each annulus subdivided, segments triannulate in the post-clitellar region.

Setae small, ventrally situated ; sometimes absent *xvii–xix*. Setal formula at *x aa* : *ab* : *bc* : *cd*=6 : 1 : 4 : 1, *dd*=$\frac{5}{7}$ circumference ; at *xv* 6 : 2 : 5 : 1, *dd*=$\frac{5}{7}$ circumference ; at *c* 6 : 1 : 4 : 1, *dd*=$\frac{5}{7}$ circumference. Genital and penial setae absent.

Clitellum saddle-shaped *xiii–xix*. Genital field raised, well-developed $\frac{1}{2}$ *xiii–xx*, seminal grooves straight, joining the prostatic pores in setal line *b* (Fig. 2a). Prostatic pores paired *xvii* and *xix*, each pore being surrounded by a pair of tumid lips.

Male pores paired *xviii*, each midway along a seminal groove.

Female pores closely paired *xiv*, slightly posteriorly to the setal ring within *aa*, distance from setal line *a* equal to *ab*.

Spermathecal pores paired 7/8, 8/9, long, slit-like, extending from within *aa* to $\frac{1}{3}$ *bc*, centre of slit in setal line *b*. Anterior wall of furrow 7/8 lappet-like, directed anteriorly tending to cover the anterior spermathecal pores.

Genital papillae 3 pairs, 13/14, 14/15, 15/16 in setal line *b*.

Internal Characters. First septum 4/5, 4/5–10/11 conical, strongly thickened, 11/12, 12/13 less so. A small pharynx extends to 4/5, the oesophagus from *v–xviii*. Anterior gizzard present *v*, the anterior region being non-muscular ; posterior gizzard *vi*. Oesophageal glands paired, lamelliform *xv–xvii* (3 pairs) ; a separate duct passes into the oesophagus from each gland. Intestine begins *xix*, intestinal caeca present *xxvii–xxx* (4 pairs), occasionally 3 or 5 on one side. Typhlosole ribbon-like, arising *xxvii*.

The dorsal vessel extends posteriorly from the dorsal union of the paired commissural vessels in *vi*. Commissural vessels present *vi–xii* increasing in size posteriorly, all apparently contractile ; they join the dorsal and ventral blood vessels. Supra-oesophageal vessel present between *vi* and the oesophageal glands, segmentally interconnected with the paired commissural vessels.

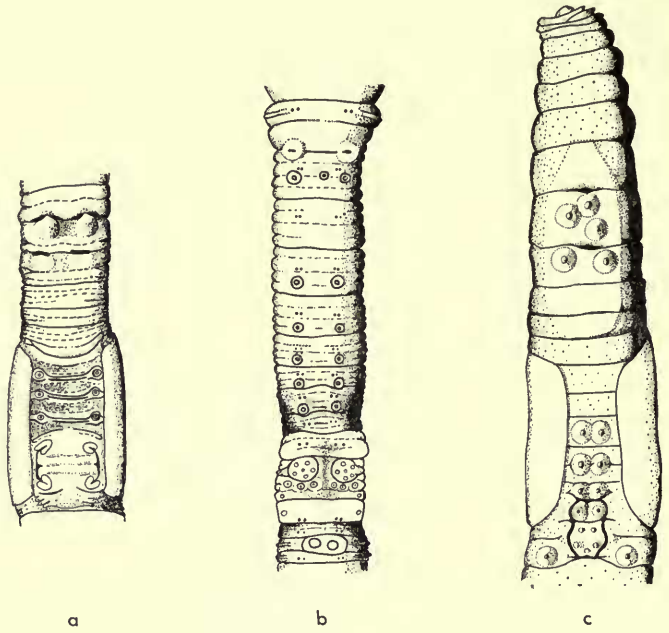

FIG. 2. a.—*Millsonia pumilia*. b.—*M. hemina*. c.—*M. ditheca*. Ventral surface showing genital field.

Testes holandric, funnels paired *x, xi*. Each testis is contained in a capsule which is continuous with a lateral horn of the funnel of its side. The ental ends of the funnels are fused medially. Seminal vesicles paired *xi, xii*, superficially racemose in appearance, septum 12/13 is slightly distended posteriorly by the bulk of the hinder vesicles. Vasa deferentia paired *xi* and *xii*, each passes into the parietal wall and joins with the other of its side to form a single duct. The ducts may be seen passing posteriorly beneath the lining peritoneum by setal line *b*. Each emerges briefly in *xvii* and passes laterally around the slender, ectal portion of the prostate before leading into the parietes.

Prostates paired, *xvii, xiv*, tubular, folded in one or two simple loops or fairly straight extending posteriorly, perhaps to *xl*. The ectal region of each prostate is modified as a slender duct.

Ovaries closely paired *xiii* ; situated on the posterior surface of septum 12/13 near to the ventral parietes. Funnels closely paired seen near to the ventral parietes anteriorly to septum 13/14.

Spermathecae paired, *viii*, *ix*, the posterior pair being larger. Each spermatheca comprises an ampulla and flexed duct of almost equal length. The duct has two diverticula, firstly a rounded, sac-like, ectal diverticulum and secondly about $\frac{1}{3}$ distance from the ectal end, a somewhat pollex-shaped diverticulum. The ampulla is simple but irregularly shaped (Fig. 3b).

Genital papillae seen internally as ovoid, glandular masses on the parietes.

Plectonephridia present as paired tufts laterally to the ventral trunks in the anterior segments as far as *xx*. Meronephridia present, three pairs in each segment from *xiii* onwards.

Remarks. Compared with other quadrithecal, quadriprostatic species of *Millsonia* this new species may be distinguished mainly by its small size and the presence of only three pairs of intestinal caeca (see Key, p. 299).

Millsonia hemina sp. nov.

2 clitellate, 4 aclitellate specimens. ?Apapam, Ghana. Date? Holotype, British Museum (Natural History) Register No. 1964.2.20 ; paratypes British Museum (Natural History) Register No. 1964.2.21/25.

Diagnosis. *External Characters*. Length 67–139 mm., diameter 1.5–3 mm. Segments 128–161. ? pigmented. First dorsal pore 9/10. Prolobous. Setae small, ventral, closely paired. Genital and penial setae absent. Clitellum *xiii*–$\frac{1}{2}$*xviii* ($7\frac{1}{2}$ segments), saddle-shaped. Male pores paired, united with paired prostatic pores *xvii* (prostatic pores absent *xiv*). Female pores paired *xiv*. Spermathecal pores paired 7/8 in setal line *b*. Genital papillae paired *viii*, *x*–*xiv* (6 pairs) in setal line *b*, paired *xiv* within *aa*.

Internal Characters. First septum 4/5, 4/5–11/12 thickened. Gizzards *v*, *vi*. Oesophageal glands paired *xv*–*xvii*. Intestine begins *xix*, intestinal caeca *xxv*, *xxvi* (2 pairs). Typhlosole ribbon-like, arising *xxiii*. Last lateral hearts *xii*. Holandric, testes paired in testes sacs, *x*, *xi*. Seminal vesicles paired *xi*, *xii*. Prostates paired *xvii* only, tubular, convoluted. Ovaries paired *xiii*. One pair spermathecae only *viii* ; duct with ectal diverticulum and another midway along length ; ampulla simple. Meronephridial.

Description. *External Characters*. Length 67–139 mm., diameter 1·5–3 mm. Segments 128–161. The caudal region (circa *cxl* onwards) of the hototype is quadrangular in cross-section. Cuticle with pale green iridescence. Epidermis ? pigmented (specimens flesh colour, preserved in alcohol). First dorsal pore 9/10. Prostomium prolobous. Most anterior segments tetrannulate, particularly the ventral surface anteriorly to the clitellum ; posteriorly to the clitellum the segments are triannulate, the middle annulus bearing the setae being slightly raised.

Setae small, closely paired. Setal formula at *x* aa : ab : bc : cd=9 : 1 : 5 : 1, *dd*=$\frac{3}{4}$ circumference ; at *xxx* 6 : 1 : 4 : 1, *dd*=$\frac{3}{4}$ circumference. Genital and penial setae absent but ventral setae somewhat stouter in the pre-clitellar region.

Clitellum saddle-shaped, *xv*–$\frac{1}{2}$*xviii* ventrally, *xiii*–*xvii* dorsally. Genital field, shield-shaped. Male and prostatic pores combined *xvii* in setal line *a*. Each pore issues from a large papilla with three smaller, supernumerary posterior papillae (Fig. 2b).

Female pores paired crescentric slits *xiv*, almost midway between setal lines *a* and *b*, anteriorly to the setae.

Spermathecal pores paired 7/8 in setal line *b*, small, transverse slits surrounded by a slightly raised, swollen circular area.

Genital papillae unpaired *viii* within *aa* otherwise paired *viii* between 2nd and 3rd annuli laterally to seta line *b*, *x–xiv* (5 pairs) between 3rd and 4th annuli in setal line *b*, *xiv* in middle annulus within *aa*.

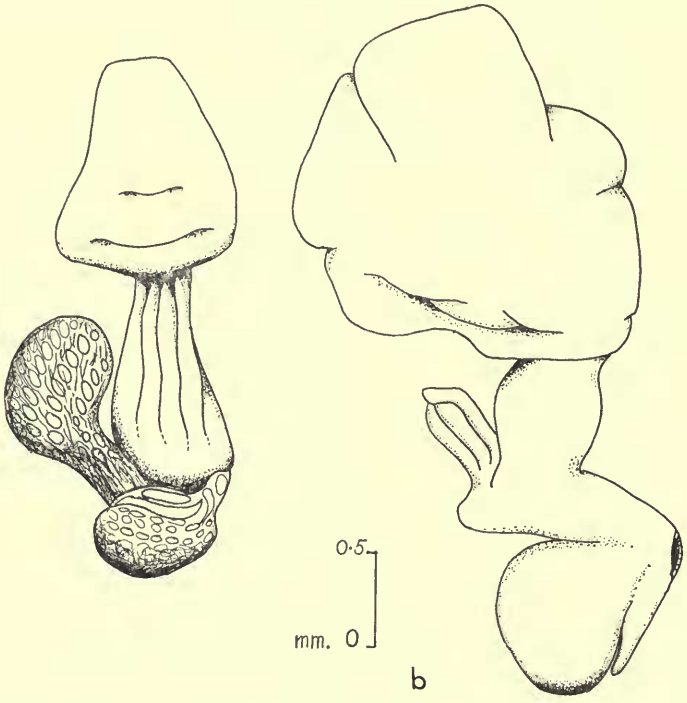

Fig. 3. Antero-dorsal view. a.—*Millsonia hemina* right spermatheca ; b.—*M. pumilia*, posterior spermatheca.

Internal Characters. First septum 4/5, 4/5–11/12 thickened, 12/13, 13/14 less so ; 4/5–7/8 strongly conical. A muscular pharynx extends to septum 4/5 ; anterior gizzard present in *v*, posterior gizzard in *vi*. The gizzards are approximately the same size, the anterior region of each is thin walled. Oesophageal glands lamelliform, paired *xv–xvii* (3 pairs), the anterior pair being slightly smaller than the others ; each gland is joined to the oesophagus by a separate duct. Intestine begins *xiv*, intestinal caeca present *xxv*, *xxvi* (2 pairs). Typhlosole ribbon-like, arising *xxiii*.

The dorsal blood vessel passes anteriorly to *v* where it terminates at the dorsal union of the paired commissural vessel of that segment. Paired commissural vessels present *v–xii*, contractile as functional lateral hearts *x–xii* (3 pairs), joining the dorsal and ventral trunks.

Testes, holandric, paired *x*, *xi*, contained within closely paired testes-sacs extending from the sperm funnels and communicating with the seminal vesicles. Seminal

vesicles paired, *xi*, *xii*, small. The two pairs of vasa deferentia unite to form a single duct on each side which passes posteriorly to *xvii*. Each duct lies on the ventral parietes and is seen as a loosely convoluted tube. Prostates, one pair only, tubular, highly convoluted lying along side the anterior region of the intestine. The ectal portion of each prostate is muscular and passes anteriorly to *xvii* where it leads into the parietes together with the vas deferens of its side.

Ovaries paired *xiii*, large, pendent from the posterior surface of 12/13 near to the ventral trunks. Funnels paired, large, each leading into a wide oviduct which passes into the parietes between setal lines *a* and *b*.

Spermathecae, one pair only, *viii*. The diameter of the ampulla is about twice that of the duct which has two diverticula of unequal size (Fig. 3a).

Excretory system combined plectonephric and meronephric. Segments anteriorly to *xii*, tufts of small nephridia clustered around the oesophagus. Meronephridia present from *xiii*, six pairs present in each segment, the lateral pairs being largest.

Remarks. This species is readily distinguishable from other species of the genus by the presence of only one pair of spermathecae opening into furrow 7/8, one pair of prostates and the fusion of the (paired) prostatic and male pores on *xvii*. Like *pumilia* it is a small *Millsonia* and further resembles this species by the small number of intestinal caeca and the presence of two diverticula on the spermathecal duct.

Millsonia ghanensis sp. nov.

Holotype : clitellate specimen, by side of deep river in stiff wet mud, Bunso, 14th May, 1954. Paratypes 20 clitellate specimens, Bunso, 22nd February 1951. Holotype, British Museum (Natural History) Register No. 1964.2.26 ; paratypes, British Museum (Natural History) Register No. 1964.2.27–46.

Other material : 11 aclitellate specimens, Bunso, 14th May, 1954. 59 aclitellate specimens, Bunso 22nd February, 1951. 19 aclitellate specimens, Bunso, 21st February, 1952. 4 clitellate, 6 aclitellate specimens, along road between Bunso and Kili, 21st February, 1952. 8 aclitellate specimens, Tafo, 8th May, 1955. 15 aclitellate specimens, grounds of Prempeh College ; mud in banks of R. Wiwi (tributary of the R. Oda which flows into the R. Osin), Kumasi, 21st March, 1956. 1 aclitellate specimen, no data.

Diagnosis. *External Characters*. Length 210–387 mm., diameter 9 mm. Segments 262–393. Unpigmented (in life, clitellum bright orange, preclitellar region vivid pink). First dorsal pore ? 12/13, 13/14. Prolobous. Setae ventral, closely paired. Genital and penial setae absent. Clitellum ½ *xiii*–½ *xx* (7 segments), saddle-shaped. Male pores paired *xviii*. Prostatic pores paired *xvii*, *xix* in setal line *b*. Female pores closely paired within setal lines *aa*. Spermathecal pores paired ⅔ *vii*, ⅔ *viii* in setal line *b*. Genital papillae closely paired 9/10–15/16 (7 pairs), 21/22–24/25 (4 pairs) within setal lines *aa*.

Internal Characters. First septum 4/5, 4/5–11/12 strongly thickened, conical, 12/13 less so. Gizzards, ½ *v*, *vi*. Oesophageal glands paired *xv*, *xvi*, *xvii*. Intestine begins *xix*, intestinal caeca *xxvii–xxxiii* (7 pairs). Typhlosole ribbon-like, begins *xxvii*. Lateral hearts *x–xiii*. Holandric, testes paired *x*, *xi*, in testis sacs ; seminal vesicles paired, *xi*, *xii*, small. Prostates paired, tubular, *xvii*, *xix*. Ovaries paired *xiii*. Spermathecae paired *viii*, *ix*, adiverticulate. Meronephridial.

Description. *External Characters.* Length 210–387 mm., diameter 9 mm. at *x*, 5 mm. at *xx*. Segments 262–393. Cuticle with slight green iridescence. Colour: preserved specimens, pale straw, epidermis unpigmented ; in life, clitellum bright orange, preclitellar region vivid pink. First dorsal pore ?12/13, 13/14. Prostomium large, prolobous.

Setae ventral, closely paired. Setal formula at *x aa* : *ab* : *bc* : *cd*=4 : 1 : 3 : 1, *dd*=$\frac{2}{3}$ circumference ; at *xv* 3·5 : 1 : 2 : 1, *dd*=$\frac{2}{3}$ (setal pairs somewhat more widely spaced) ; at *c* 6 : 1 : 4 : 1, *dd*=$\frac{2}{3}$ circumference.

Segment *v* biannulate ; *vi*, *vii* triannulate ; *viii–xi* tetrannulate ; *xii–xv* pentannulate ; postclitellar region triannulate. Clitellum indistinct, ? saddle-shaped, $\frac{1}{2}$ *xiii*–$\frac{1}{2}$ *xx* (7 segments) extending ventrally nearly to setal lines *dd*. Genital field poorly developed, $\frac{2}{3}$ *xvi*–$\frac{1}{3}$ *xx* ; seminal grooves laterally convex, joining the prostatic pores of each side in setal line *b*.

Male pores paired *xviii*, in the seminal grooves, apparently in setal line *b* (*xvii–xix* setae *b* absent, setal lines *cd* displaced laterally).

Female pores closely paired *xiv* within setal lines *aa*, situated slightly anteriorly to the setal ring ; distance from setal line *a* being nearly equal to *ab*.

Spermathecal pores large, paired $\frac{2}{3}$ *vii*, $\frac{2}{3}$ *viii* within setal lines *ab*. Pores separated from the posterior furrows by 1 annulus, annuli adjacent to the pores, swollen.

Genital papillae closely paired 9/10–15/16 and 21/22–24/25 within setal lines *aa*. Within the genital field, indistinct, paired genital markings.

Internal Characters. First septum 4/5, 4/5–11/12 strongly thickened, conical, 12/13 less so.

Pharynx small, extends posteriorly to 4/5. A small portion of undifferentiated oesophagus in *v* precedes a small anterior gizzard extending to 5/6, large posterior gizzard in *vi* displaces septum 6/7 posteriorly against 7/8. An unpaired, oesophageal pouch is also present in *vi*, it is small and thin-walled and situated median dorsally. Oesophageal glands paired *xv*, *xvi*, *xvii* ; anterior smallest, posterior pair largest. Intestine begins *xix*, wide anteriorly and pouch-like due to intersegmental constrictions *xx–xxvi*. Intestinal caeca present, digitiform, small *xxvii–xxxiii* (7 pairs). Typhlosole begins in *xxvii* as a double fold pendent from the median dorsal line of the interior of the intestine ; when separated the folds are seen to be ribbon-like.

The dorsal blood vessel extends posteriorly from the dorsal surface of the pharynx, anteriorly it is slender but increases in diameter as it passes over the dorsal surfaces of the gizzards and reaches its greatest size in *xiv*. Commissural vessels seen *vii–xiii*, contractile as functional lateral hearts *x–xiii*. The commissural vessels join the dorsal and ventral blood vessels. Anteriorly the ventral vessel is clearly seen lying on the ventral nerve cord but in the segments bounded by thickened, conical septa, it is partly enclosed in the thickened tissue of the septa for most of the length of these segments. A supraoesophageal blood vessel passes posteriorly from *vii–xiii* with segmentally paired branches to the commissural vessels. In *xiv* the supraoesophageal vessel bifurcates and each branch passes into a loose plexus of blood vessels interconnecting the oesophageal glands in *xv–xvii*. A suboesophageal blood vessel was not seen.

Testes holandric, closely paired in sacs immediately below the oesophagus on the posterior surfaces of septa 9/10, 10/11 ; funnels situated on the anterior surfaces of septa 10/11, 11/12 respectively near to the ventral nerve cord. These septa are strongly conical so that the funnels appear to lie on the ventral wall of the segment. Seminal vesicles paired *xi*, *xii*, small ; seen as depressed granular pouches arising from the posterior surfaces of septa 10/11, 11/12. Vasa deferentia are difficult to trace, the two pairs apparently remain separate on each side. Prostatic glands paired *xvii*, *xix*, tubular, long, highly convoluted except for a straight muscular, ectal portion. The prostates enter the parietes a short distance from the ventral nerve cord.

Ovaries paired, *xiii*, free, funnels small, oviducts not seen.

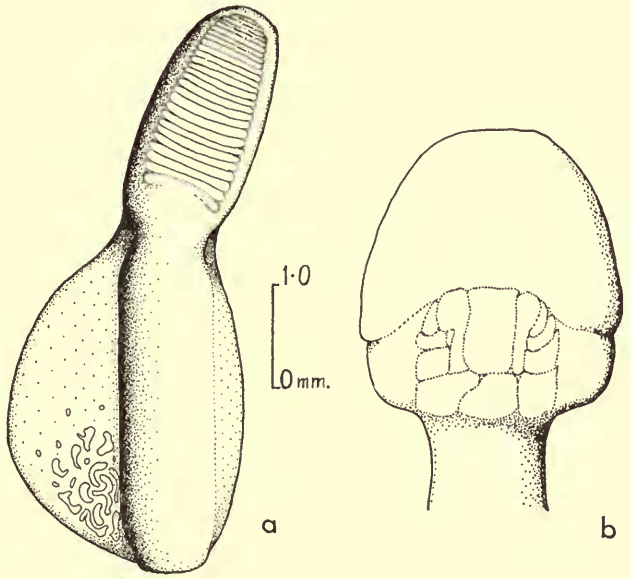

Fig. 4. Posterior spermathecae. a.—*Millsonia ghanensis*, antero-dorsal view ; b.—*M. ditheca*, ventral view.

Spermathecae paired, *viii*, *ix*, the ducts pass obliquely into the parietes by the anterior septum of the segment. Each is digitiform but a slight constriction between the ampulla and duct gives a somewhat clavate appearance. A fin-like process is present along the lateral surface of each duct (Fig. 4a), also the medial surface in riper individuals. The fins are semitransparent and numerous small, vesicular diverticula may be seen through the tissue. Posterior spermathecae slightly larger than the anterior pair.

Excretory system meronephridial. Anteriorly tufts of small nephridia are

clustered on the anterior surfaces of the septa near to the oesophagus, posteriorly from *xiv* they are situated on the perietal wall in a single lateral row in each segment. First pair of larger meroneophridia present in *xix*.

Remarks. In comparison with other large, western African, tetrathecate species of *Millsonia*, this new worm is slenderer in general proportions. It may be readily distinguished externally by the arrangement of the closely paired genital papillae. Excluding the region of the genital field, each pair of papillae is situated intersegmentally on a single, raised, oval area ; a raised oval area occurs in each furrow from 9/10 to 24/25 (in less well-developed individuals the papillae are present only in furrows 9/10 to 15/16). Internally, the strongly thickened anterior septa, 4/5–11/12 and to some extent 12/13, and the short series of intestinal caeca, *xxvii–xxxiii* (7 pairs), also serve to distinguish the species.

Millsonia ditheca sp. nov.

1 clitellate, 17 aclitellate specimens, soil beneath cocoa trees, Tafo, 26th October, 1955. 1 clitellate specimen, Tafo, 17th October, 1952. Holotype, British Museum (Natural History) Register No. 1964.2.170 ; paratypes, British Museum (Natural History) Register No. 1964.2.171–188.

Diagnosis. *External Characters.* Length 128, 140 mm., diameter 4·5, 5 mm. Segments 264, 272. Unpigmented. First dorsal pore ?10/11, 11/12. Prolobous. Setae small, ventral, closely paired. Genital and penial setae absent. Clitellum *xiii–xvii* (5 segments), saddle-shaped. Male pores paired *xviii*. Prostatic pores very closely paired *xvii*, *xix*. Female pores closely paired *xiv*. Spermathecal pores single, median ventral, 7/8, 8/9. Anterior genital papillae irregular *viii*, *ix* ; posterior genital papillae paired *xv–xix*.

Internal Characters. First septum 4/5, 4/5–12/13 thickened. Gizzard *vi*. Oesophageal glands paired *xv–xvii*. Intestine begins *xix*, intestinal caeca *xxvii–xxxiv* (8 pairs). Typhlosole ribbon-like, arising *xxviii*. Lateral hearts *x–xii*. Holandric, testes paired in sacs *x*, *xi*, small, funnels short but wide ; seminal vesicles paired, *xi*, *xii*, small. Prostates paired, tubular, *xvii*, *xix*. Ovaries paired, *xiii*. Spermathecae, single, *viii*, *ix*, adiverticulate, passing around either right or left side of ventral trunks, posterior spermatheca larger. Meronephridial.

Description. *External Characters.* Length 128, 140 mm., diameter 4·5, 5 mm. Segments 264, 272 (clitellate specimens). Cuticle with slight blue-green iridescence ; epidermis unpigmented, general colour creamy white, darker posteriorly where the gut-contents may be seen through the gut and body walls, clitellum orange-brown (specimens preserved in alcohol). First dorsal pore ?10/11, 11/12, not seen in the clitellar segments. Prostomium prolobous. Segments tetrannulate in the preclitellar region with the first and fourth annuli narrower than the second and third, strongly triannulate posteriorly to the clitellum.

Setae small, ventrally situated, very closely paired. Setal formula at *x* and *xv* *aa* : *ab* : *bc* : *cd*=4 : 1 : 3 : 1, *dd*=$\frac{4}{5}$ circumference ; at *c* 7 : 1 : 4 : 1, *dd*=$\frac{4}{5}$ circumference. Setae near spermathecal pores undifferentiated. Penial setae absent.

Clitellum saddle-shaped, *xiii–xvii* (5 segments) extending ventrally almost to setal line *b*. Genital field small, restricted to *xvii–xix*, intersegmental furrows indistinct ; seminal grooves paired, sinuate, joining the prostatic pores of each side.

Male pores paired *xviii*, each being situated in a seminal groove at the point of intersection with a lateral (? intersegmental) furrow (Fig. 2c). Prostatic pores very closely paired in *xvii* and *xix*, each pair opens into a lateral furrow near to the midventral line.

Female pores closely paired *xiv*, situated in the setal ring within *aa*, distance from $a=ab$.

Spermathecal pores single, median ventral in furrows 7/8, 8/9. Ventral surface of $\frac{2}{3}$ *vii–ix* swollen. Anterior genital papillae irregularly arranged, 2 on *viii*, 3 on *ix*, ventrally within setal lines *cc*. Posterior genital papillae paired, *xv* in setal line *b*, *xvi*, *xvii*, *xviii* in setal line *a*, *xix* in setal line *d* (Fig. 2c).

Internal Characters. First septum 4/5, 4/5–12/13 thickened, 11/12 and 12/13 only moderately thickened.

A large pharynx extends posteriorly to 5/6, strongly muscular in posterior region of *v* ; oesophageal gizzard *vi*. The oesophagus extends to *xviii* with paired lamelliform oesophageal glands in *xv*, *xvi*, *xvii* ; the septa of these segments are slightly displaced anteriorly, the anterior pair of glands occupying part of *xiv*. A duct issues from the hilus of each gland and passes into the oesophagus. The intestine begins in *xix*, paired intestinal caeca present *xxvii–xxxiv* (8 pairs) decreasing in size posteriorly. (Anteriorly to the caeca, *xix–xxvi*, the intestine is slightly dilated segmentally into a series of paired, thin-walled pouches). Typhlosole ribbon-like, arising in *xxviii* ; it is attached along the centre of its dorsal surface to the mid-dorsal line of the internal surface of the gut. In the region of the intestinal caeca the width of the typhlosole is equal to nearly one-third of the circumference of the intestine, posteriorly to this region it is slightly narrower and equal to about one quarter of the circumference.

The dorsal blood vessel extends posteriorly from the dorsal surface of the pharynx in *iv*, paired commissural vessels join it with the ventral blood vessel in *vi–xii*, functional as lateral hearts only in *x–xii*. The ventral blood vessels leads posteriorly from the ventral surface of the pharynx in *iv*. A median supraoesophageal blood vessel extends posteriorly from *vi* with paired branches interconnecting it segmentally with the paired commissural vessel and dorsal blood vessel. It passes posteriorly along the dorsal surface of the oesophagus to *xvii* where a median branch enters the dorsal blood vessel, then in *xviii* the main trunk appears to enter the dorsal blood vessel.

Testes holandric and funnels paired, *x*, *xi*. Testes small, enclosed in vesicles pendent from the posterior surface of the anterior septum of *x* and *xi* ; situated near to the ventral trunks being almost sub-oesophageal. Funnels truncate but wide, also near to the ventral trunks. Seminal vesicles small, paired *xi*, *xii*, granular in appearance. A single pair of vasa deferentia lie on the parietes near to the ventral nerve cord, passing posteriorly to *xviii* where the ducts enter the parietes. Prostates tubular, paired *xvii*, *xix*, loosely coiled entering the parietes latero-ventrally to the nerve cord.

Ovaries small, paired *xiii*, funnels and oviducts not seen.

Spermathecae single, median ventral *viii*, *ix*, the posterior spermatheca being

twice the size of the anterior one. Each consists of a large, simple, pyriform ampulla and squat, adiverticulate duct (Fig. 4b). Both lie slightly to one side of the vertical median plane and each duct curves around and slightly displaces the ventral trunks to enter into the parietes in the mid-ventral line by septa 7/8 and 8/9 respectively. The spermathecae may curve around the right or left side of the ventral trunks.

Internally the genital papillae are seen as ovoid, glandular masses in the parietes.

Excretory system meronephridial. Tufted nephridia grouped medially on the septa of *iv–xi*. From *xii* posteriorly, meronephridia distributed laterally in two regular rows on the parietal wall of each segment ; from *xix* posteriorly, each nephridium comprises a simple loop, terminal vesicle absent.

Remarks. The median ventral, unpaired spermathecae in furrows 7/8 and 8/9 clearly distinguish *ditheca* from all other known species of *Millsonia*. Although *M. eudrilina* (Cognetti, 1909) was described with one unpaired spermatheca this new species appears, from description, to be closer to the tetrathecate *M. anomala* Omodeo, 1955, from the Ivory Coast. It differs from the latter species mainly on the number of spermathecae and intestinal caeca.

M. ditheca shows some affinities with species of *Wegeneriella* Michaelsen, a genus not recognised by Pickford (1937 : 80) on the grounds that it is a heterogenous assemblage containing convergent species. The main generic characters of *Wegeneriella* are the presence of unpaired spermathecae and two pairs of oesophageal glands in *xiv* and *xv*. In *M. ditheca* the oesophageal glands in *xv* appear superficially to be double and occupy part of *xiv* but as there are also separate paired glands in *xvi* and *xvii* in addition to the presence of intestinal caeca and a broad, ribbon-like typhlosole, I place this species in *Millsonia* Beddard, sensu Omodeo (1955 : 218).

Remarks on the genus *Millsonia*. The new species of *Millsonia* described above further extend our knowledge of the range of morphological variation in the genus (Omodeo, 1958 : 59). Until now species of *Millsonia* have been regarded as containing large individuals but with the descriptions of *hemina* and *pumilia* come the first details of small worms. It is interesting to note, moreover, that there are few intestinal caeca in these species, particularly, in the smaller, *hemina*, where there are only two pairs, *xxv*, *xxvi*, whereas in the much larger *caecifera* (Benham) there is a series of 24 pairs, *xxix–lii*.

The number of spermathecae is variable in *Millsonia*, the tetrathecate condition is the commonest and is, presumably, the primitive condition of the genus. However, the anterior pair of spermathecae are wanting in *mimus* (Michaelson), *nigra* Beddard and *sokodeana* (Michaelson) while in *eudrilina* (Cognetti) there is only one spermathecal pore being median ventral in furrow 8/9. Now two other conditions have been found, in *hemina* the posterior pair of spermathecae are wanting (functionally this condition may be correlated with the reduction in the number of prostates) and in *ditheca* there are two unpaired, median ventral spermathecae in furrows 7/8, 8/9.

In the new species described above it would seem that most variations are independent of others although, as already mentioned, some are apparently correlated, e.g. the two smallest species, *hemina* and *pumilia*, have the least number of

intestinal caeca. Generally all of these new worms would seem to consist of a mosaic of primitive and specialised characters. In the case of the tiny *hemina*, the most obvious feature is the small size, a character which is usually regarded as a criterion of a less specialised condition, yet the spermathecal and male reproductive systems are highly modified. In the absence of palaeontological evidence and knowledge of the rates of evolution of species and organ systems, I do not propose to follow fallacious precedents and arrange the species in a phylogenetic sequence on the morphological complexity of one organ system, e.g. nephridia.

The worms collected by Miss Tazelaar do not extend the known range of *Millsonia*, in fact, Ghana appears to be about the centre of the distribution of the genus. Omodeo (1955 : 217) figured a map showing every locality where specimens of each species of *Millsonia* had been collected, from this it is clear that the genus is confined to the rain forests in western Africa south of the River Niger.

Genus ***Millsonia*** Beddard

KEY TO SPECIES, AFTER OMODEO, 1958 : 59

1	Spermathecal pores in or near furrow 7/8 *and* 8/9	2
–	Spermathecal pores in furrow 7/8 *or* 8/9	10
2	Spermathecal pores single (median ventral 7/8 and 8/9)	***M. ditheca*** sp. nov.
–	Spermathecal pores paired	3
3	Penial setae present, tusk-like, pitted (genital papillae absent, ducts of spermathecae fused together and with parietal wall)	***M. schlegeli*** (Horst, 1884)
–	Penial setae absent	4
4	Genital papillae absent (anterior and posterior spermathecae of equal size)	***M. insignis*** (Michaelsen, 1922)
–	Genital papillae present	5
5	Last lateral hearts in segment *xii*	6
–	Last lateral hearts in segment *xiii*	8
6	1 gizzard present (segment *vi*)	***M. anomala*** Omodeo, 1955 : 219
–	2 gizzards present (segments *v* and *vi*)	7
7	Intestinal caeca numerous, *xxix–lii* 24 pairs, (body length long, circa 500 mm.)	***M. caecifera*** (Benham, 1894)
–	Intestinal caeca few, *xxvii–xxx* 4 pairs, (body length short, circa 100 mm.)	***M. pumilia*** sp. nov.
8	14–15 pairs of intestinal caeca, *xxx–xliii, xliv* ; (spermathecal pores in setal lines *c*)	***M. inermis*** (Michaelsen, 1892)
–	7 pairs of intestinal caeca	9
9	Intestinal caeca *xxvii–xxxiii* (spermathecal pores in setal lines *b*)	***M. ghanensis*** sp. nov.
–	Intestinal caeca *xxxvi–xlii* (spermathecal pores in setal lines *d*)	***M. heteronephra*** (Michaelsen, 1897)
10	Spermathecal pores in furrow 7/8	***M. hemina*** sp. nov.
—	Spermathecal pores in furrow 8/9	11
11	Spermathecal pore single, median ventral	***M. nigra**** Beddard, 1894
—	Spermathecal pores paired	12
12	Prostatic pores between setal lines *ab* (diameter of body circa 12 mm.)	***M. mimus*** (Michaelsen, 1891)
—	Prostatic pores between setal lines *bc* (diameter of body circa 4 mm.)	***M. sokodeana*** (Michaelsen, 1913*a*)

**Minigra* Beddard, 1894 and *M.eudrilina* (Cognetti, 1909) are synonymous (Sims, *in prep.*).

EUDRILIDAE

Libyodrilus sp.

Libyodrilus: Clausen, 1965. Vidensk. Medd. fra Dansk naturh. Foren., **128** (in press).

7 clitellate, 5 aclitellate specimens ; Ho, south eastern Ghana, 29th December, 1957.

Description. *External Characters.* Length 106–132 mm., diameter 4–4·5 mm. Segments 159–174 (clitellate specimens). Colour pale greyish flesh above, whitish grey below, clitellum lilac ; cuticle with slight bluish green iridescence and pink reflections (specimens preserved in alcohol). Dorsal pores absent. Prostomium prolobous.

Clitellum annular extending over nearly four segments, $\frac{1}{3}$ *xiv*–$\frac{2}{3}$ *xvii*. Setae lumbricine, closely paired, ventrally situated. Setal formulae at *x aa* : *ab* : *bc* : *cd* : =6 : 1 : 4 : 1, *dd*=$\frac{3}{4}$ circumference ; at *xv* 4 : 1 : 3 : 1, *dd*=$\frac{3}{4}$ circumference ; at *xxx* 6 : 1 : 4 : 1, *dd*=$\frac{3}{4}$ circumference. Paired penial setae 1·04 mm. long present on the male papilla, each is slightly curved distally.

Male pore single, median ventral in furrow 17/18, raised on a small setose papilla extending $\frac{2}{3}$ *xvii*–$\frac{1}{3}$ *xviii*.

Female pores inconspicuous, paired, *xiv* near furrow 14/15, dorsally to setal line *d* at distance of 5*cd*.

Spermathecal pore single, median ventral in *xiii* as a small transverse slit slightly posteriorly to the setal ring.

Nephridiopores paired, inconspicuous, in the posterior wall of each furrow, dorsally to setal line *d* at distance 4*cd*.

Internal Characters. First septum 5/6, 5/6–11/12 thickened ; all septa in the preclitellar region are strongly conical. The buccal cavity opens into a muscular pharynx extending into *iv*, the oesophagus passes posteriorly from *v* to *xix* where the intestine begins ; oesophageal gizzard, glands and appendages absent. The first four segments of the intestine, *xix–xxii*, form a thin-walled crop which is followed by three gizzards in *xxiii–xxv* with thin-walled intersegmental pouches in 23/24 and 24/25. A low typhlosole begins in *xxviii* as a small longitudinal ridge along the dorsal surface of the lumen of the intestine.

Paired lateral hearts in *vi–xii*, these commissural vessels are long and somewhat convoluted, the more posterior pairs are stouter and ? more strongly contractile ; any pair may be inequally developed. The commissural vessels join the dorsal and supraoesophageal blood vessels with the ventral blood vessel. The dorsal blood vessel extends posteriorly from the dorsal union of the paired commissural vessel in *vi*, from *xii–xxi*, ?*xxii* it is bifurcated segmentally but reunites to pass through the septa, appearing as a series of rings. The supraoesphageal blood vessel extends posteriorly from the pharynx to septum 12/13 where it enters the dorsal blood vessel. The sub-oesophageal blood vessel passes along the ventral surface of the oesophagus from the pharynx to *xii* where it dilates and bifurcates as it passes through septum 12/13 then each branch gives off a side branch to the adjacent lobe of the receptaculum seminis in *xiv–xvi*, the main branches continue posteriorly to the euprostates.

Testes holandric, paired in *x* and *xi* near to the ventral parietes within folds of the posterior surface of septa 9/10 and 10/11. Funnels paired in *x* and *xi*, they are directed anteriorly and seen as large, white-iridescent foliations in the posterior region of the segments laterally to the ventral trunks. Seminal vesicles paired in *xi* and *xii*, small, lobulate. Each vas deferens remains separate and those of each side pass closely together to the (paired) euprostatic gland of its side which it enters about midway along the lateral surface. The euprostates are paired in *xviii*, small and flexed posteriorly they reach only to *xix*. Ectally the two euprostates pass into the ventral parietes adjacent to the ventral trunks between *xvii* and *xviii*, displacing septum 17/18 slightly anteriorly.

Ovaries paired in *xiii*, small, each is enclosed by an ovarian vesicle on the posterior surface of septum 12/13. As the septum is strongly conical the ovaries are situated on a laterally facing surface (Fig. 5), while the medial region of the septum lies within the parietes of *xv*. A short, stout oviduct leads from each ovary to a (paired)

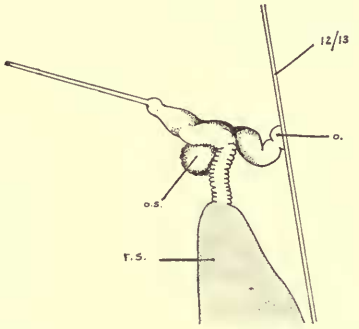

FIG. 5. *Libyodrilus* sp. female reproductive system, left side, dorsal view ; *o.*, ovary ; *o.s.*, ovisac ; *r.s.*, receptaculum seminis ;*12/13*, septum 12/13 (passing obliquely).

ovisac, which communicates with the fertilization chamber. Sperm pass to this chamber from the receptaculum seminis, ectally it narrows and forms an egg duct which passes antero-laterally towards the parietes.

The spermathecal system consists of a single receptaculum seminis lying above the oesophagus mainly in *xiv–xvi* with a pair of ventral lobes in each segment. Dorsally to the anterior pair of lobes, a pair of ducts extend antero-ventrally on either side of the oesophagus and the ventral trunks in *xiii*. Medially they are flexed where they meet and pass into the parietes midventrally below the nerve cord. (Due to the posterior displacement of the contents of the coelomic cavity, these anterior horns of the receptaculum join ventrally to the posterior pair of seminal vesicles). The lobes form one large ring around both the oesophagus and the nerve cord and do not coalesce between them. The anterior extremity of each lobe in *xiv* leads into the fertilisation chamber which forms part of the female system.

Excretory system meganephridial ; in those anterior segments containing the lateral hearts, the nephridial tubules are long and much convoluted whereas in the clitellar region the nephridia are small.

Remarks. This species is placed in the genus *Libyodrilus* Beddard (1891*c*) mainly on the presence of intestinal gizzards and the absence of an oesophageal gizzard, glands or appendages. The specimens from Ho are similar to *L. violaceus* Beddard (syntype examined) (Gates, 1962) but differ mainly in that the anterior horns of the receptaculum seminis form one large ring around both the oesophagus and the nerve cord compared with two separate rings joined by a single, median duct ; they are also slightly smaller. They differ from *L. kamerunensis* Michaelsen, 1915, in the same characters but, in addition, they are holandric like *violaceus* whereas *kamerunensis* is metandric.

Eudrilus buettneri Michaelsen, 1892

Eudrilus buettneri Michaelsen, 1892, Arch. Naturg. esch. **58** : 256 :–Bismarckburg, Togoland.

7 clitellate, 3 aclitellate specimens, roadside, between Bunsu and Kili, 21st February, 1952. 2 clitellate, 9 aclitellate specimens, Tafo, 17th October, 1952. 4 clitellate specimens, Tafo, 14th May, 1954. 1 clitellate specimen, Prempeh College, 21st March, 1956. 2 clitellate specimens, Ho, 28th December, 1957.

Description. *External Characters*. Length 142–171 mm., diameter 4–5 mm. Number of segments 162–198 (8 specimens, remainder damaged). Cuticle with azure blue iridescence ; colour vinous purple above otherwise unpigmented, i.e. pale straw below (specimens preserved in alcohol). Dorsal pores absent. Prostomium epilobous. The clitellum extends over slightly more than four segments, *xiv*–$\frac{1}{3}$ *xviii*, saddle-shaped (Fig. 6a).

The setal arrangement is lumbricine ; setal formulae at *x aa* : *ab* : *bc* : *cd* : *dd*= 5 : 1 : 4 : 1 : 25. dd=$^3/_5$ circumference ; at *xv* 4 : 1 : 3 : 1 : 14, *dd*=$\frac{1}{2}$ circumference ; at *xxx* 6 : 1 : 4 : 1 : 18, *dd*=$\frac{1}{2}$ circumference. Penial setae absent.

Male pores paired in furrow 17/18 as narrow, transverse slits extending laterally from setal line *b*, surrounded by tumid lips with scalloped radial ridges.

Female and spermathecal pores combined, paired in furrow 13/14 extending from midway between setal lines *bc* to line *c*, surrounded by smooth, tumid lips.

Nephridiopores paired, near anterior furrow of each segment, midway between setal lines *c* and *d*.

Internal Characters. First septum 4/5, 7/8–9/10 thickened, 10/11 11/12 less so. The buccal cavity opens into the pharynx which extends to *iv*. An oesophageal gizzard in *v* occupies $\frac{1}{2}$ *v–vii* and causes septa 5/6, 6/7 to become conical by displacing them posteriorly against 7/8. The oesophagus extends to $\frac{1}{2}$ *xiii* where the intestine commences. Oesophageal glands are present in *x*, *xi* as unpaired median ventral pouches and in *xii* as a pair of lateral, stalked glands.

Paired lateral hearts in *viii–x* join the dorsal and ventral blood vessels ; they also interconnect the supraoesophageal blood vessel with the dorsal blood vessel as it passes between the pharynx and the paired oesophageal glands in *xii*.

Testes holandric, paired in *x* and *xi*, each is enclosed in a testis sac. Near to the oesophagus each testis sac communicates with the seminal vesicle in the succeeding segment. More laterally each sac passes into a modified funnel or sperm sac which leads into a vas deferens. Seminal vesicles paired in *xi* and *xii*, smooth, the hinder pair displaces septum 12/13 slightly posteriorly. Each vas deferens passes posteriorly over the ventral parietes, laterally to the ventral trunks. In *xvii* each is flexed laterally then loops back to enter the ectal end of the euprostatic gland of its side. Euprostatic glands paired, extending from *xvii–xxii* ; in *xviii* the ectal end of each gland is directed posteriorly where it enters the medial surface of the (paired) copulatory chamber, more entally the glands curl laterally or dorsally and pass back to the region of *xxii*. The copulatory chambers are small, simple, domed pouches ; in diameter each is twice the length of the segment and slightly displaces septum 17/18 and 18/19 posteriorly.

The ovaries are paired in *xiii* and lie on the posterior face of septum 12/13 near to the ventral parietes, adjacent to the ventral nerve cord (Fig. 6b). Each is enclosed by a vesicle from which a duct passes postero-laterally to the paired female/spermathecal apparatus and into the ovisac (Michaelsen, 1892 : 257, showed the duct leading into the receptaculum seminis). Each spermathecal system comprises a

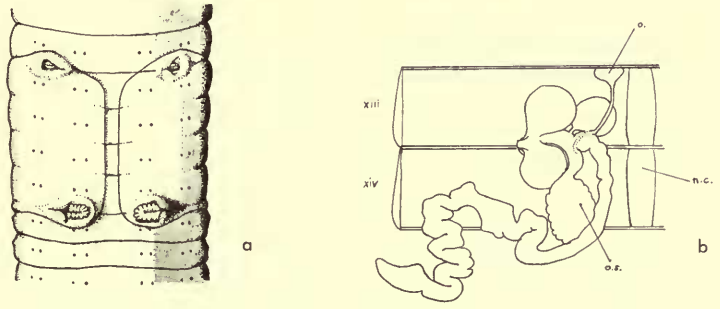

Fig. 6. *Eudrilus buettneri* ; a.—Clitellar region, ventral surface. b.—Female and spermathecal systems, left side, dorsal dissection ; *n.c.*, ventral nerve cord ; *o.*, ovary ; *o.s.*, ovisac.

short atrium leading from the female/spermathecal pore, ectally there are two spherical diverticula, more entally a stout duct leads from the posterior surface into the ovisac and a short slender duct leads from the anterior surface into another spherical diverticulum. Entally a thinner walled receptaculum seminis leads from the atrium, this is long and convoluted and occupies most of the coelomic space available in *xiv*.

Excretory system meganephridial, the nephrostome is near to the ventral parietes ; each nephridium is suspended from the anterior septum by a membrane nearly one quarter of the length of the segment. The reservoir of each nephridium is thick-walled and the middle portion of the nephridial duct is highly convoluted.

Remarks. *Eudrilus buettneri* has been recorded only once, when the unique, aclitellate holotype was described from Bismarckburg, Togoland. The worms fom Tafo agree with the description but many being clitellate, provide further information of the external morphology (the original description is also supplemented with other details of anatomy).

Michaelsen (1900 : 402) placed *E. buettneri* in the synyonymy of *E. pallidus* Michaelsen, 1891, but eventually regarded it as a variety of the latter (1913 : 39). The status of *E. buettneri* is still no clearer ; the present series shows that this worm is widely distributed in south-eastern Ghana also other specimens in the collections of the British Museum (Natural History) come from Aburi, that is, from localities fairly near to Accra from where *E. pallidus* was described. It seems unlikely that the specimens of these taxa are representatives of allopatric populations of the same species in view of the propinquity of the collecting stations. In the absence of evidence of their being ecological representatives, I propose to regard the two taxa as separate species on the differences listed between them by Michaelsen (1913*b* : 42) which I found to be constant in the series examined.

Eudrilus eugeniae (Kinberg, 1866)

Lumbricus eugeniae Kinberg, 1866, Ofvers. Vetensk Akad. Förh. Stockh., **23** : 98 :– St. Helena.

60 clitellate, 11 aclitellate specimens. Aburi, 1st June, 1956.

Hyperiodrilus africanus Beddard, 1891

Hyperiodrilus africanus Beddard, 1891, Quart, J. micr. Sci., n.ser. **32** : 236.

2 clitellate specimens. Prempeh College grounds, Kumasi. 17th November, 1955.

Hyperiodrilus marthae sp. nov.

1 clitellate specimen. Damp soil under roadside grass, Ketekrachi, south-eastern Ghana. 14th February, 1951. Holotype, British Museum (Natural History) Register No. 1963.10.120.

Diagnosis. *External Characters.* Length 96 mm., diameter 3 mm. Segments 202. Unpigmented. Dorsal pores absent. Proepilobous. Clitellum annular. Setae eudriline, $ab > cd$, penial setae absent. Male pore single, median ventral in furrow 17/18. Porophores absent. Female pores paired in anterior wall of furrow 14/15 in line with the nephridiopores. Spermathecal pore single, median ventral *xii* (in posterior wall of furrow 11/12). Nephridiopores paired, midway between setal lines *c* and *d*.

Internal Characters. First septum 4/5, 5/6–10/11 thickened. Oesophageal gizzard absent, intestinal gizzards *xvii–xxiv* (8). Oesophageal glands paired *xiii*, unpaired median ventral pouches *ix*, *x*, *xi*. Last lateral hearts *xi*, *?xii*. Holandric, testes in testis sacs on posterior septa of *x*, *xi*. Seminal vesicles small. Euprostates small, leading separately to male pore. Ovaries paired *xiii*, enclosed in ovarian vesicles. (Spermathecal system apparently not fully developed). Meganephridial.

Description. *External Characters.* Length 96 mm., diameter 3 mm. Segments 202. Cuticle, slight yellow-green iridescence ; areas bounded by setal lines *a* and *b*, also *c* and *d* reflect separately from the areas bounded by *a* and *a*, also *b* and *c*.

Colour pale straw, pigment apparently absent (specimen preserved in alcohol). Dorsal pores absent. Prostomium proepilobous. The clitellum is annular and extends over 4 segments, *xiv–xvii*.

Setae eudriline, $ab > cd$. Setal formulae at *x aa* : *ab* : *bc* : *cd* : *dd* = 5 : 3 : 5 : 2 : 75, $dd = \frac{2}{3}$ circumference ; at *xxx* 3 : 2 : 4 : 1 : 50, $dd = \frac{2}{3}$ circumference (setae *cd* absent in the clitellar region). Penial setae absent.

Male pore single, median ventral in furrow 17/18 on a papilla extending $\frac{1}{2}$ *xvii*–$\frac{1}{2}$ *xviii*, the posterior border of the papilla being lappet-like (Fig. 7a).

Female pores paired in near the anterior wall of furrow 14/15 in the line of the nephridiopores (setae *cd* missing in *xiv*, *xv*).

Spermathecal pore single, median ventral, small, slightly swollen transverse slit in the posterior wall of furrow 11/12 i.e. in *xii*.

Nephridiopores paired in the posterior wall of each furrow midway between setal lines *c* and *d*, starting in 2/3.

Internal Characters. First septum 4/5, 5/6–10/11 thickened, first five septa strongly conical, the next four less so. The buccal cavity opens into the pharynx extending to *v*. The oseophagus extends to *xiii*, the intestine commences in *xiv*. The first three segments of the intestine from *xiv–xvi* are dilated to form a crop, a series of eight intestinal gizzards is present in *xvii–xxiv*. Oesophageal calciferous glands are present as unpaired, median ventral pouches in *ix*, *x*, *xi* and as paired lateral ducted glands in *xiii*.

Paired lateral hearts are present *vi–xi*, a paired non-contractile, commissural vessel is also present in *xii* ; these pass from the dorsal to the ventral blood vessels with interconnections with the supra-oesophageal vessel. The latter passes along the dorsal surface of the oesophagus between the pharynx and a plexus of blood vessels in *xiii* draining the paired calciferous glands. A suboesophageal vessel passes along the ventral surface of the oesophagus from the pharynx over the median calciferous glands in *ix*, *x*, *xi* and descends in *xii* to form the sub-neural blood vessel.

Testes holandric, paired in *x* and *xi*, each is situated near to the posterior septum of its segment within a U-shaped testis sac. Each sac communicates postero-dorsally with the seminal vesicle of the next segment and ventrally narrows to become a vas deferens before passing posteriorly through the septum. The vasa deferentia remain separate and extend posteriorly along setal line *c* to the euprostate of that side. Both euprostates are directed anteriorly but they are sharply flexed and the ental portion lies dorsally, above the ectal part ; both are 5–6 mm. long. In *xviii* the vasa deferentia pass anteriorly along the lateral surface of each euprostate which they enter in the ental third. Ectally the two euprostates pass into the parietes in the anterior part of *xviii*, laterally to the nerve cord.

The ovaries are paired, each is enclosed in an ovarian vesicle lying on the ventral parietes in *xiii* near to septum 12/13, the lateral apex of the sac being adjacent to the vasa deferentia. The ovarian duct of each side was not seen. (There are several coelomic membranes in the vicinity of the ovarian vesicle forming a number of intra-coelomic chambers, one communicates with the fertilization chamber at the ental end of the oviduct).

The spermathecal system consists of an atrium leading from the parietes at septum 11/12, ectally it is three times the width of the nerve cord but as it passes posteriorly it gradually tapers. In the anterior region of *xiii* the extension of the atrium comes to lie to the left of the ventral nerve cord where a delicate, membranous duct joins it with the left fertilisation chamber ; then with four dorso-ventral flexures it leads across beneath the central nerve cord to near the right fertilisation chamber. Here another delicate membranous duct joins the right chamber with the atrial extension which continues posteriorly and ends blindly by the anterior surface of septum 14/15 (Fig. 7b).

Excretory system meganephridial, one pair of nephridia in each segment commencing in *iii*.

Remarks. Compared with other species of *Hyperiodrilus*, the position of the spermathecal pore of *H. marthae* is intermediate between that in *H. lagosensis* where it occurs on *xi* and in *H. africanus* on *xiii*, in addition there are more intestinal gizzards. The specimen is not fully adult, the testes and seminal vesicles are small, the spermathecal system is poorly developed and there are no ovarian ducts passing between the ovaries and the fertilisation chambers.

Hyperiodrilus prosothecaporus sp. nov.

1 clitellate specimen. Ho. 28th December, 1956. Holotype, British Museum (Natural History) Register No. 1963.10.121.

Diagnosis. *External Characters*. Length 57 mm., diameter 1·5 mm. Segments 125. Colour (preserved in alcohol) white anteriorly, greyish posteriorly, clitellum cream. Dorsal pores absent. Epilobous. Clitellum annular. Setae eudriline, $ab > cd$. Penial setae absent. Male pore single, mid-ventral 17/18. Female pores paired *xiv*, one quarter of distance from setal line *c* to setal line *d*. Spermathecal pore single, mid-ventral *ix* near furrow 9/10. Nephridiopores paired, midway between setal lines *c* and *d*.

Internal Characters. First septum 4/5, 5/6–10/11 thickened, moderately conical. Nonmuscular oesophageal dilation *v*, intestinal gizzards *xix–xxii* (4). Oesophageal glands single, mid-ventral *ix*, *x*, *xi*, paired, lateral *xiii*. Last hearts *xi*. Holandric, vasa deferentia lead into ental end of euprostates, copulatory pouch present. Ovaries paired *xiii*, paired ovarian duct leads to fertilisation chamber in *xiv*. from where oviduct passes to the exterior. Spermathecal atrium leads posteriorly from *ix* to *xiv* where it enters the perispermathecal sinus which encircles the oesophagus and is connected with the fertilisation chambers. Meganephridial.

Description. *External Characters*. Length 57 mm., diameter 1.5 mm. Segments 125. Cuticle with slight green iridescence. Pre-clitellar region white-cream colour, clitellum cream, post-clitellar region pale grey (specimen preserved in alcohol). Dorsal pores absent. Prostomium epilobous. Clitellum annular, *xiv–xvii* (4 segments).

Setae eudriline, $ab > cd$. Setal formulae throughout, $aa : ab : bc : cd = 2 : 1\frac{1}{2} : 3 : 1$, $dd = \frac{1}{2}$ circumference. Penial setae absent.

Male pore single, small lateral slit, mid-ventral in furrow 17/18 leading into a small copulatory pouch in *xviii* ; pore surrounded by two tumid lips, the anterior lip

being formed from part of the posterior region of *xvii* and the posterior lip from part of the anterior region of *xviii*.

Female pores paired *xiv*, near to the posterior margin of the segment by furrow 14/15, situated about one-quarter of the distance from setal line *c* to *d*, i.e. midway between the line of the nephridiopores and setal line *c*.

Spermathecal pore single, midventral, slit-like, apparently forming part of furrow 9/10 but on opening the lips the entrance to the spermathecal atrium is seen to be in *ix*. The lips of the pore are formed partly from the posterior region of *ix* and the anterior region of *x*.

Nephridiopores paired, beginning ?2/3, 3/4. The pore is always situated a short distance posteriorly to the furrow, midway between setal line *c* and *d*.

Genital papillae and markings absent.

Internal Characters. First septum 4/5, 5/6–10/11 thickened, moderately conical. Small buccal cavity opens into a large muscular pharynx extending to *iv*. The oesophagus begins in *v* and passes posteriorly to *xiv*, it is dilated in *v* to form a small, thin-walled, non-muscular chamber. The intestine begins in *xv*, a crop is present *xv–xviii*, in the anterior region of *xix* the intestinal wall is thickened by a chitinoid ring, also in *xx–xxiii*, thus forming a series of 4 intestinal gizzards in *xix–xxii*. Typhlosole rudimentary extending posteriorly from *xxvii*, represented by a slight narrow ridge along the mid-dorsal line of the interior of the intestine. Oesophageal glands present as unpaired, ventral pouches *ix*, *x*, *xi*, the first in *ix* is small and poorly developed. Paired lateral glands present in *xiii*, pouch-like in appearance due to the stalks being short and broad.

Dorsal blood vessel extends anteriorly to the dorsal union of the paired commissural blood vessel in *vi*, reaching its fullest development in the segments anteriorly to the paired oesophageal glands. Paired commissural vessels join it with the ventral vessel in *vi–xi*, all apparently being contractile ; a more slender, paired commissural vessel in *xii* appears to pass from the dorsal vessel to the sub-neural vessel. A supraoesophageal vessel passes between the pharynx and the paired oesophageal glands in *xiii*. The dorsal and supra-oesophageal vessels are interconnected segmentally by paired commissural vessels. A sub-oesophageal vessel leads posteriorly from beneath the pharynx, following the profile of the oesophageal pouches in *ix*, *x*, *xi*. Posteriorly to these segments it is difficult to distinguish this vessel in the preserved specimen but either it, or a branch, passes ventrally to the left side of the ventral nerve cord to become the sub-neural vessel.

Testes holandric paired *x*, *xi*, enclosed in bean-shaped testes sacs pendent from the posterior septum of their segment. A slender duct issues from the dorsal end of each testis sac and passes posteriorly through the septum into the seminal vesicle in the following segment. Seminal vesicles paired *xi*, *xii*, small racemose. A vas efferens leads from the ventral end of each testis sac, it passes obliquely posteriolaterally before flexing and turning posteriorly. The vasa efferentia of each side unite in *xii* to form a single (paired) vas deferens. The paired vas deferens continues posteriorly over the parietal wall to the euprostates. Euprostatic glands paired, *xv–xviii*. The vasa deferentia pass into the ental (anterior) end of the glands which

taper ectally, in *xviii*, before turning medially and leading into a single median, depressed copulatory pouch. The copulatory pouch is circular with a diameter almost equal to the distance between septa 17/18 and 18/19.

Ovaries paired, *xiii*, each is enclosed within an ovarian vesicle near to the ventral parietes and pendent from the posterior face of septum 12/13. An ovarian duct passes posteriorly to the ovisac in *xiv* which is joined to the fertilisation chamber in *xiii* (these chambers are closely applied to septum 13/14 which is partly wrapped around the fertilisation chamber and separating it from the ovisac). The oviduct leads posterolaterally from the fertilisation chamber to the parietal wall anteriorly to septum 14/15. A diverticulum is present on the oviduct about one-third of the distance from the fertilisation chamber to the parietes. In length it is about half as long as the oviduct, it is medially directed and its distal end lies close by the ventral nerve cord.

Spermathecal atrium single, ovoid, extending from the hinder part of *ix* to septum 10/11. It continues as a narrower, comparatively thin-walled duct to the anterior region of *xiv* where it bifurcates to form a pair of small lateral horns (Fig. 7c). The horns are enclosed within a small transparent, membranous dome-shaped vesicle

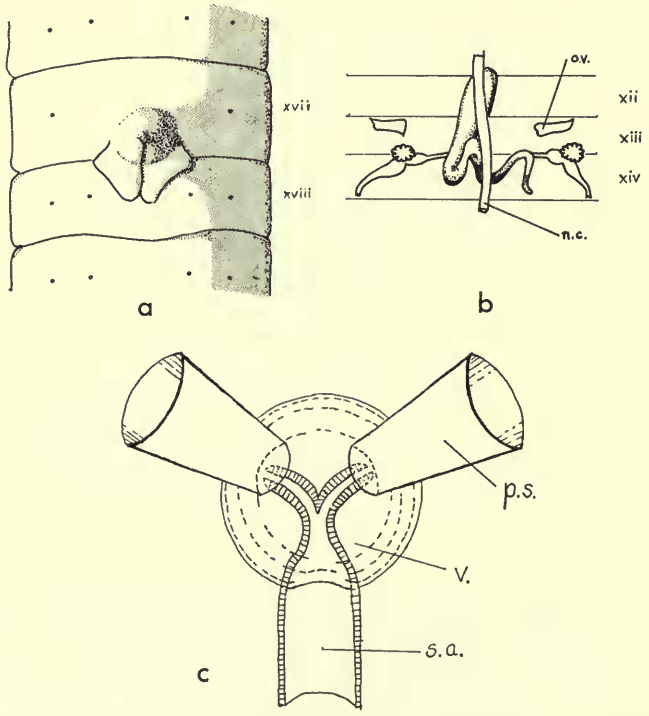

FIG. 7. *Hyperiodrilus marthae* : a.—Ventral surface showing male pore ; b.—Female reproductive and spermathecal systems, dorsal dissection. *ov.*, ovary ; *n.c.*, ventral nerve cord ; c.—*H. prosothecaporus* : diagram, spermathecal vesicle, dorsal dissection. *p.s.* perispermathecal sinus ; *s.a.*, spermathecal atrium ; *v.*, vesicle.

which is continuous with a pair of lateral, perispermathecal sinuses. The sinuses pass from each side of the dome to the fertilisation chambers, then dorsally where they unite to complete a circumoesophageal ring. Spermathecal sac not seen.

Excretory system meganephridial, one pair of meganephridia to each segment ; nephridia uniform throughout the body.

Remarks. *H. prosothecaporus* may be readily distinguished from all other known species of *Hyperiodrilus* by the anterior position of the spermathecal pore in furrow 9/10. This condition appears to be primitive for it is in the same region as the pore(s) in the Ocnerodrilidae, the family which may represent the grade of structure of a common ancestor, or, as Stephenson (1930 : 864) believed, the family from which the Eudrilidae has actually evolved.

The oesophagus of *H. prosothecaporus* is dilated in segment *v* but the structure is not regarded as forming an oesophageal gizzard since it is thin-walled and non-muscular being apparently of little functional importance. It is, however, of some taxonomic significance and the species has been placed in the genus *Hyperiodrilus* chiefly on this single character. The genus *Legonea* may be distinguished from *Hyperiodrilus* mainly by the presence of a functional oesophageal gizzard in segment *v* (Clausen, 1963 : 2 ; Sims, 1964 : 592). An oesophageal gizzard is present in most other Eudrilid genera and the dilation in the fore-gut of segment *v* of *H. prosothecaporous* could represent a relict structure.

The primitive situation of the spermathecal pore and the presence of a vestigial oesophageal gizzard have not been previously recorded in *Hyperiodrilus* so it could be that this species is a more primitive member of the genus than most, while the vestigial gizzard serves to link *Hyperiodrilus* more closely with *Legonea*. A further resemblance is to be found in the male reproductive system of this species which is moderately specialised in that the male pore opens into a small copulatory pouch similar to that in the somewhat specialised, rather aberrant species *Legonea rapta* in which a penis and copulatory appendages are also present. It is interesting to note that in both *H. prosothecaporus* and *L. rapta*, porophores and genital papillae are absent. In all other species of *Hyperiodrilus* and *Legonea* the male pores are very closely paired at the apex of a V-shaped seminal groove where they are regarded as forming a single pore and there is a porophore at each end of the seminal groove.

The structure of the spermathecal system and its particular stage of development in the specimen described above may provide a solution to the problem of the origin of the perispermathecal sinuses in a species of the closely related genus *Legonea*. *L. modesta* has a spermathecal system almost identical with those of species of *Hyperiodrilus*. In one young specimen of *L. modesta* the spermathecal ducts were found to be little more than buds at the posterior end of the spermathecal atrium, while apart from a small, triangular, membraneous vesicle lying dorsally to the dorsal blood vessel and the oesophagus, there was no trace of the sinuses (Sims, 1964 : 590). It was suggested that the sinuses may be derived by differentiation of the existing coelomic membranes or from the peritoneum which could form a sheath to the inthrusting, developing spermathecal ducts. This present specimen apparently represents the next stage in the development of the perispermathecal sinuses. It

shows clearly that they are formed entirely from coelomic membranes. This is evident since the sinuses encircle the oesophagus, extending from the posterior end of the atrium to where they unite above the dorsal blood vessel, yet the spermathecal ducts extend only a short distance from the atrium (Fig. 7*c*). The late development of the ducts also indicates that they do not act as organisers and induce the differentiation of the coelomic membranes into the perispermathecal sinuses.

Genus ***Hyperiodrilus*** Beddard

Key to species

	Intestinal gizzards	Spermathecal pore Segment No.
prosothecaporus sp. nov.	*xix–xxii* (4)	*ix* (near 9/10)
millsoni (Beddard, 1893)	*xviii–xxii* (5)	*x*
lagosensis (Beddard, 1891)	*xviii–xxiii* (6)	*xi*
marthae sp. nov.	*xvii–xxiv* (8)	*xii* (near 11/12)
africanus Beddard, 1891	*xvi–xxii* (7)	*xiii*

Legonea hyperiodriloides Clausen, 1963

Legonea hyperiodriloides Clausen, 1963, Vidensk. Medd. fra Dansk naturh. Foren., **126** : 2.–Legon, 10 miles N.E. of Accra, Ghana.

85 clitellate specimens, Nimghah Farm, Ahulu, 20th June, 1956.

Legonea modesta Sims, 1964

Legonea modesta Sims, 1964, Proc., zool. Soc. Lond., **143** : 595.–Ketekrachi, southeastern Ghana.

15 clitellate, 1 aclitellate specimens (syntypes), 14th February, 1951. 1 aclitellate specimen, Tafo, 14th May, 1954.

Legonea rapta Sims, 1964

Legonea rapta Sims, 1964, Proc. zool. Soc. Lond., **143** : 601.–Jangebunga, southeastern Ghana.

58 clitellate specimens (holotype and paratypes), 10th December, 1951.

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